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Mortality attributed to respiratory problems among finisher pigs in the United States

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Abstract

In the 1995 National Swine Study of the United States National Animal Health Monitoring System, producers identified respiratory problems as the leading cause of death in pigs during the grower/finisher phase of production. Over a six-month period, 61.7±4.1% (mean±SEM) of operations reported at least one death attributed to respiratory problems among finisher pigs (based on 388 operations representing operations with ≥300 finisher pigs in 16 states). Mean mortality attributed to respiratory problems was 0.9±0.1% of finisher pigs per operation. Stepwise logistic regression (using SAS) was used to identify factors associated with operations attributing at least one death to respiratory problems, and to identify factors associated with reporting ≥2% mortality attributed to respiratory problems. Final models were run with SUDAAN to account for the sampling strategy. Attributing at least one death to respiratory problems was associated with having ≥3000 pigs enter the grower/finisher unit over a six-month period; diagnosis of *Haemophilus* (or *Actinobacillus*) in the past 12 months; and keeping pigs in the grower/finisher unit >120 days (as compared to <100 days). Not having a farrowing facility, mean weaning age <28 days, and <50% of finisher pigs on solid concrete only were associated with reporting ≥2% mortality attributed to respiratory problems.

Keywords: Respiratory disease; Pig-microbiological diseases; Mortality; Health monitoring; National Animal Health Monitoring System (NAHMS)

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1. Introduction

The increasing intensification of pork production (encompassing expansions in both, the size and density of pork-production facilities) may have created conditions amenable to the spread of agents associated with swine-respiratory problems (Christensen and Mousing, 1992; Clermont and Désilets, 1982). In both the United States National Animal Health Monitoring System (NAHMS) 1990 National Swine Survey and the NAHMS 1995 National Swine Study, the leading producer-identified cause of mortality among finisher pigs was respiratory problems, which accounted for over 40% of deaths in each study (United States Department of Agriculture, 1997). High-density housing systems may lead to the presence of a high concentration of various air contaminants associated with respiratory problems in pigs (Donham, 1991). Herd size, season, stocking density, hygiene, feed, manure management, whether all-in/all-out management is used, proximity to the nearest operation with pigs, and vaccination programs represent possible risk factors for swine-respiratory disease (Stark et al., 1998). Respiratory disease in pigs is, in many ways, related to scours (Willeberg et al., 1978). Tillon and Kobisch (1987) recommend regular monitoring for respiratory disease by a veterinarian and monitoring for respiratory disease at slaughter.

Manure management can have an impact on air quality and swine-respiratory health. Gases produced by swine manure include carbon dioxide (CO_2), methane (CH_4), ammonia (NH_3) and hydrogen sulfide (H_2S) (Bate et al., 1988). Ammonia and hydrogen sulfide can cause inflammations in the respiratory tract (Bate et al., 1988). Donham (1991) found that several air contaminants (including dust, ammonia, carbon dioxide, and microbes) were correlated with pneumonia and pleuritis in pigs. Slotted flooring can be effective in separating pigs from their excrement (Fritschen and Mueling, 1993).

Many swine-respiratory illnesses are quite contagious (Christensen and Mousing, 1992; Fenwick et al., 1986). Disease outbreaks – particularly in large, concentrated operations – may result in severe economic losses for pork producers (Van Arsdall and Nelson, 1985).

Using data from the second stage of data collection for the NAHMS 1995 National Swine Study (which included operations with $\geq$300 finisher pigs in 16 states), Losinger et al. (1998) examined overall mortality (due to all causes) in the grower/finisher phase of swine production. High mortality ($\geq$4%) was associated with a mean weaning age <28 days, not vaccinating for *Escherichia coli* scours, and not acquiring all finisher pigs from farrowing units belonging to the operation. The purpose of this paper is to report the results of analyses identifying potential risk factors for death loss attributed to respiratory problems in the grower/finisher phase of swine production in the United States. The results could be used by producers to identify areas where attention should be focused, and by researchers to identify future areas of study.

2. Materials and methods

The design and implementation of the NAHMS 1995 National Swine Study have been described (Losinger et al., 1998). SUDAAN (a computer program designed for the

analysis of survey data; Shah et al., 1996) was used to compute the percent of operations with various levels of mortality attributed to respiratory problems during the six-month period prior to the final interview for the NAHMS 1995 National Swine Study. In addition, SUDAAN was used to compute the percent of operations with at least one finisher-pig death attributed (by the producer) to respiratory problems by 98 questionnaire variables (previously listed, Losinger et al., 1998) thought potentially to be associated with mortality in the grower/finisher phase of production. SUDAAN's chi-square test was used to select variables for inclusion in multivariable models ($p \leq 0.25$). To examine relationships among the screened variables, Spearman rank correlations (Hogg and Craig, 1978) were computed from the CORR procedure of SAS (Statistical Analysis Systems Institute, 1990).

As previously described (Losinger et al., 1998), forward stepwise logistic regression ($\alpha = 0.05$) (Hosmer and Lemeshow, 1989), with the PROBIT procedure of SAS (Statistical Analysis Systems Institute, 1989), was used to identify management factors associated with an operation attributing at least one finisher-pig death to respiratory problems. Region, herd size (as measured by the number of swine that entered the grower/finisher phase of production on the operation), presence or absence of a farrowing phase on the operation, and average days in the grower/finisher unit were forced into the model to prevent variables from entering the model merely because they were related to these variables. Region and herd size were reflective of the sample selection for the study design. The presence or absence of a farrowing phase was forced into the model because management practices do differ between farrow-to-finish producers and only-grower/finisher operations. Average number of days in the grower/finisher unit was forced into the model because one would expect to observe higher mortality with more days at risk. The LOGISTIC procedure of SUDAAN (Shah et al., 1996) was then applied to the model developed from SAS to derive weighted parameter estimates and standard errors adjusted for the study's stratification and clustering. Non-forced variables with $p > 0.05$ were removed from the model developed with SUDAAN. The same procedures were followed to identify factors associated with an operation experiencing $\geq 2\%$ mortality attributed to respiratory problems.

3. Results

Out of the 418 operations that participated in the second stage of data collection for the NAHMS 1995 National Swine Study, 391 (93.5%) provided mortality information because of attributed cause in the grower/finisher production phase during the six months prior to the final interview (which took place between November 6, 1995, and January 17, 1996). Within the sample, 277 (70.8%) operations attributed at least one finisher-pig death to respiratory problems. The method of diagnosis (e.g. necropsy, clinical observation) was not specified in the survey. Maximum mortality attributed to respiratory problems was 25.0%, and the sample median (including operations with no deaths attributed to respiratory problems) was 0.42%. Table 1 summarizes national estimates (computed from SUDAAN) of the distribution of mortality attributed to respiratory problems. Table 2 provides descriptive statistics for screened variables.

Table 1
Percent of operations by percent mortality attributed to respiratory problems among finisher pigs during the six months prior to interview (388 operations, 1995 National Swine Study, USA)

Percent mortality	Percent of operations [a]	Standard error
0	38.3	4.1
>0, <0.5%	19.3	3.0
≥0.5, <1%	13.4	2.5
≥1, <2%	16.5	2.7
≥2, <4%	7.6	1.9
≥4%	4.8	1.9
	100.0	

[a] An estimated 0.2±0.1% of operations reported no mortality during this time period.

Table 2
Percent of operations that attributed any mortality to respiratory problems and that reported ≥2% mortality to respiratory problems among finisher pigs during the six months prior to interview for forced variables and for risk factors with $p \leq 0.25$ in unconditional testing (1995 National Swine Study, USA)

Risk factor	*n*	At least one death		≥2% Cause-specific mortality	
		percent	SE	percent	SE
Forced variables					
A. Region					
north	87	56.2	9.4	22.2	8.9
midwest	240	62.9	5.0	11.2	3.0
southeast	61	61.2	9.6	9.2	6.0
B. Number of pigs that entered the grower/finisher phase in the six months prior to interview					
<800	143	55.7	5.7	12.9	3.7
800–2999	156	68.2	5.5	10.5	2.9
≥3000	89	97.7	2.0	19.5	7.9
C. Operation has a farrowing facility					
yes	334	58.7	4.4	9.1	2.0
no	54	74.7	10.2	27.3	9.7
D. Average days in the grower/finisher unit					
<110	116	48.7	7.5	6.5	2.5
110–120	116	63.4	7.5	13.1	5.1
>120	142	70.5	6.3	17.4	4.9
Screened variables					
E. *Haemophilus* diagnosed in finisher pigs by a veterinarian or laboratory in last 12 months					
yes	67	95.4	3.1	—	—
no	321	58.1	4.3	—	—
F. Mean age at weaning					
<28 days	202	68.6	5.4	14.7	3.5
≥28 days	131	51.8	6.2	5.1	2.4
no farrowing facility	54	74.7	10.2	27.3	9.7
G. Percent of finisher pigs on solid concrete flooring only					
<50%	246	73.3	4.7	—	—
>50%	141	50.0	6.2	—	—

Table 2 (*Continued*)

H. Average age at entering the grower/finisher unit					
≤60 days	215	66.7	5.3	16.5	3.8
>60 days	159	52.3	6.3	5.7	2.1
I. Finisher pigs have outside access					
yes	107	54.2	6.9	9.1	2.7
no	275	67.2	4.7	15.2	3.9
J. All finisher pigs originated from on-site farrowing and nursery units belonging to the operation in the last six months					
yes	271	57.2	4.7	7.6	2.0
no	117	73.3	7.7	25.0	7.1
K. Total confinement in grower/finisher phase					
yes	230	69.3	5.1	14.8	3.8
no	152	54.8	6.1	10.6	3.5
L. Pit-holding waste management in grower/finisher phase					
yes	186	74.0	5.3	17.8	5.1
no	196	52.8	5.6	8.9	2.2
M. Home-computer based record-keeping system used					
yes	134	72.3	6.6	13.3	6.1
no	254	58.1	4.8	12.2	2.7
N. Feral pigs are a health threat					
yes	31	38.0	13.6	9.3	5.6
no	253	63.9	4.1	12.8	2.7
O. Regularly vaccinate for erysipelas					
yes	304	66.1	4.3	8.5	1.9
no	84	51.5	8.6	21.7	6.9
P. Regularly vaccinate for *E. coli* scours					
yes	243	57.8	5.1	7.5	2.1
no	145	69.5	6.5	22.3	6.0
Q. Regularly vaccinate for leptospirosis					
yes	318	58.1	4.5	7.4	1.7
no	70	73.5	9.1	28.9	8.5
R. Typically gave finisher pigs antibiotics or other agents as disease preventives or growth promotants in feed or water					
yes	348	63.5	4.3	13.3	2.8
no	38	44.5	12.2	3.9	3.3
S. Chlortetracycline given to finisher pigs					
yes	146	68.6	6.4	11.2	3.1
no	240	57.8	5.2	13.2	3.6
T. Oxytetracycline given to finisher pigs					
yes	37	81.1	8.0	11.5	8.8
no	349	59.9	4.3	12.6	2.7
U. Percent of finisher pigs on concrete-slats flooring only					
<50%	256	56.4	4.8	10.9	2.9
≥50%	131	82.7	5.2	18.7	5.6

Table 2 (*Continued*)

V. Below-floor slurry or deep-pit waste-storage system used					
yes	236	67.7	5.0	15.6	4.3
no	152	55.6	6.3	9.3	2.5
W. Trucks and trailors used for transporting livestock allowed to cross the perimeter of the swine operation					
yes	301	57.3	4.7	12.6	2.9
no	87	81.1	4.8	11.8	5.2
X. Porcine reproductive and respiratory syndrome diagnosed in finisher pigs by a veterinarian or laboratory in last 12 months					
yes	98	86.0	4.7	20.7	6.2
no	290	58.4	4.5	11.3	2.8

The logistic-regression models were developed for 376 operations that provided data for all of the screened variables. Operations where $\geq$3000 pigs entered the grower/finisher production phase over the six-month period prior to the final interview were more likely to attribute at least one death to respiratory problems than smaller operations, but herd size was not a factor for $\geq$2% mortality (Table 3). Operations where pigs spent an average of >120 days in the grower/finisher unit were more likely to attribute at least one death or $\geq$2% mortality to respiratory problems than operations where pigs spent an average of <110 days in the grower/finisher unit. In addition, operations where *Haemophilus* (or *Actinobacillus*) had been diagnosed in finisher pigs by a veterinarian or laboratory within the previous 12 months were more likely to have at least one death attributed to respiratory problems. Operations with their own farrowing facility were less likely to have $\geq$2% mortality attributed to respiratory problems than operations that did not have their own farrowing facility. Weaning age <28 days and $\leq$50% of finisher pigs only on solid concrete flooring was associated with $\geq$2% mortality attributed to respiratory problems.

Table 4 presents Spearman rank-correlation coefficients between model variables and screened variables that did not enter the models. Herd size was correlated ($\rho \geq 0.4$) with whether pigs were on concrete slats flooring and that porcine reproductive and respiratory syndrome virus had been diagnosed in the herd during the previous 12 months. Whether the operation had a farrowing facility was correlated with whether all pigs originated from farrowing and nursery units belonging to the operation and with the operation-vaccinated pigs for erysipelas, *E. coli* scours, and leptospirosis. Days in the grower/finisher unit was correlated with average age at entering the grower/finisher unit. The percentage of finisher pigs on solid concrete flooring was correlated with whether finisher pigs had outside access, whether pig-holding waste-management was used, percentage of pigs on concrete-slats flooring, and whether a below-floor slurry or deep-pit waste-storage system was used.

4. Discussion

Limitations involved in using data from the NAHMS 1995 National Swine Study to analyze overall mortality among finisher pigs have been discussed (Losinger et al., 1998).

Table 3
Final multivariable logistic-regression model of grower/finisher swine operations attributing at least one death to respiratory problems during the six months preceding interview, and final logistic-regression model of grower/finisher swine operations reporting ≥2% mortality attributed to respiratory problems during the six months preceding interview (376 operations, 1995 National Swine Study, USA)

Variable/response	At least one death			≥2% Cause-specific mortality		
	odds ratio	95% CI	*p*	odds ratio	95% CI	*p*
Haemophilus diagnosed in finisher pigs in last 12 months by a veterinarian or laboratory						
yes	12.6	2.66–59.3	<0.01	—	—	—
no	1	—	—	—	—	—
Mean age at weaning						
<28 days	—	—	—	3.53	1.16–10.8	0.03
≥28 days	—	—	—	1	—	—
no farrowing facility	—	—	—	1	—	—
Percentage of finisher pigs on solid concrete flooring only						
<50%	—	—	—	6.53	2.20–19.4	<0.01
≥50%	—	—	—	1	—	—
Region (forced into model)						
north	0.74	0.22–2.56	0.64	1.61	0.31–8.44	0.58
midwest	0.92	0.32–2.63	0.88	0.56	0.13–2.47	0.45
southeast	1	—	—	1	—	—
Number of pigs that entered the grower/finisher phase in the six months prior to interview (forced into model)						
<800	0.04	0.01–0.20	<0.01	1.54	0.42–5.58	0.52
800–2999	0.50	0.01–0.37	<0.01	0.80	0.23–2.81	2.81
≥3000	1	—	—	1	—	—
Operation has a farrowing facility (forced into model)						
yes	0.43	0.12–1.51	0.19	0.13	0.04–0.46	<0.01
no	1	—	—	1	—	—
Average days in the grower/finisher unit (forced into model)						
<110 days	0.30	0.12–0.75	0.01	0.24	0.07–0.79	0.02
110–120 days	0.60	0.24–1.48	0.27	0.54	0.19–1.50	0.24
>120 days	1	—	—	1	—	—

Producers were asked the number of finisher pigs that had died due to scours, lameness, trauma, respiratory problems, other known and unknown problems. A limitation of using these data to examine cause-specific mortality is that many producers might not have known the exact cause of a pig's death. While 'respiratory problems' was the leading producer-identified cause of death, the second leading response was 'unknown problem', followed by 'other known problem' (United States Department of Agriculture, 1997). Some of the pigs that died from unknown problems might have died from respiratory disease. In addition, if a pig had multiple disease problems preceding its death (for example, scours and respiratory problems), the producer was constrained to select one category in which to attribute the cause of death. Willeberg et al. (1978) reported that respiratory disease and scours were interrelated. Therefore, some of the finisher pigs that died from causes attributable to diseases other than respiratory may have also had respiratory disease problems that contributed to the mortality.

Table 4
Spearman rank correlation coefficients between model variables and screened variables which did not appear in final multivariable models. Table 2 shows the variable names which the letters indicate. Spearman rank correlation coefficients for average weaning age (F) are limited to operations with a farrowing facility. Numbers in parenthesis represent $p>|\rho|$ under $H_0:\rho=0$

	Variable [a]					
	B	C	D	E	F [a]	G
H	0.09 (0.07)	0.08 (0.12)	−0.44 (<0.01)	0.04 (0.49)	0.02 (0.70)	−0.09 (0.08)
I	0.31 (<0.01)	−0.02 (0.69)	−0.06 0.21	−0.13 (0.01)	−0.27 (<0.01)	−0.42 (<0.01)
J	0.22 (<0.01)	−0.59 (<0.01)	−0.02 (0.70)	−0.14 (0.01)	−0.14 (0.01)	−0.09 (0.07)
K	−0.29 (<0.01)	0.04 (0.43)	0.01 (0.91)	0.09 (0.07)	0.30 (<0.01)	0.30 (<0.01)
L	−0.10 (0.05)	0.12 (0.02)	−0.01 (0.93)	0.02 (0.67)	0.07 (0.18)	0.40 (<0.01)
M	−0.29 (<0.01)	−0.01 (0.80)	−0.01 (0.83)	0.06 (0.27)	0.20 (<0.01)	0.15 (<0.01)
N	−0.09 (0.09)	0.02 (0.69)	0.03 (0.58)	0.04 (0.45)	0.07 (0.19)	0.04 (0.45)
O	−0.02 (0.66)	−0.50 (<0.01)	−0.13 (0.01)	0.00 (0.97)	0.12 (0.02)	0.08 (0.09)
P	−0.05 (0.32)	0.44 (<0.01)	0.07 (0.18)	0.00 (0.96)	0.04 (0.42)	0.06 (0.22)
Q	−0.02 (0.75)	−0.75 (<0.01)	−0.05 (0.36)	0.01 (0.88)	0.13 (0.01)	−0.01 (0.81)
R	0.03 (0.55)	−0.11 (0.03)	0.03 (0.53)	0.00 (0.96)	−0.04 (0.46)	−0.12 (0.02)
S	0.03 (0.62)	0.05 (0.37)	0.02 (0.76)	0.01 (0.81)	−0.03 (0.58)	0.06 (0.27)
T	−0.02 (0.67)	0.05 (0.32)	−0.01 (0.83)	−0.01 (0.81)	0.04 (0.49)	−0.01 (0.87)
U	0.40 (<0.01)	−0.04 (0.38)	−0.07 (0.17)	−0.15 (<0.01)	−0.23 (<0.01)	−0.43 (<0.01)
V	−0.25 (<0.01)	0.09 (0.06)	−0.02 (0.71)	0.07 (0.17)	0.19 (<0.01)	0.42 (<0.01)
W	0.02 (0.64)	0.13 (0.01)	−0.00 (0.99)	0.02 (0.65)	−0.03 (0.60)	0.01 (0.82)
X	−0.44 (<0.01)	−0.04 (0.39)	−0.02 (0.67)	0.26 (<0.01)	0.27 (<0.01)	0.20 (<0.01)

[a] Correlations between mean age at weaning and other variables use only operations with a farrowing facility.

This study did not look at pigs culled for respiratory illness as a dependent variable. Culling pigs for respiratory illness may potentially reduce the effective mortality rate. However, we do not know whether those pigs would have died or not if left in the grower/finisher unit. We also do not know whether pigs culled for respiratory problems would have spread respiratory-disease agents to other pigs, nor what effect this would have had on mortality. Culling rate was examined as a potential risk factor (Losinger et al., 1998), but did not enter the final models.

Another limitation of the study is that data on a number of environmental risk factors (e.g. pig density, pigs per building, air quality, ambient temperature, type of ventilation system) were not collected. However, enough information was collected to pinpoint some risk factors for mortality caused by respiratory problems in finisher pigs.

Considerable diversity of opinion exists over whether sample weights and information about the sample design should be used in multivariable models (Groves, 1989). In this study, some differences between the statistical significance of certain parameters for SAS (which assumes simple random sampling) and SUDAAN (which takes into account the sample weights and design) were noted. However, both models yielded similar conclusions; we present only the results for SUDAAN.

One might certainly have anticipated that operations where more pigs had entered the grower/finisher unit would have been more likely to have at least one finisher pig die of respiratory illness, as larger operations had more total pigs at risk (Table 3). However, no significant operation-size differences in $\geq 2\%$ respiratory mortality were observed. Moreover, one might have foreseen that operations that kept pigs in the grower/finisher facility longer would have experienced higher mortality (as noted here), as the at-risk period was longer. In contrast, no statistically significant differences were detected in mortality due to all causes based on length of time in the grower/finisher unit (Losinger et al., 1998).

Clermont and Désilets (1982) reported higher mortality among finisher pigs on grower/finisher-only operations than on farrow-to-finish operations. Operations that do not have their own farrowing facility (and hence must bring in all of their pigs from outside the operation) may be at increased risk of introducing fatal respiratory diseases to the herd. The results of the NAHMS 1995 National Swine Study indicated that $\approx 20\%$ of grower/finisher producers received feeder pigs from sources not belonging to the operation and, of these, roughly one-half obtained feeder pigs from more than one source (United States Department of Agriculture, 1996). The number of operations receiving feeder pigs from multiple sources was, therefore, too small to examine its effect on respiratory mortality. Producers must be careful about where they obtain pigs in order to avert the introduction of diseases (Bäckström and Bremer, 1978; Robertson et al., 1992).

A limitation of this study is that producers were only asked whether specific disease-causing organisms in finisher pigs had been diagnosed by a veterinarian or laboratory in the previous 12 months (Losinger et al., 1998). No information was collected on the number of pigs affected, nor on specific treatments administered. Furthermore, different producers may have had different thresholds for identifying, treating and reporting diseases. In some cases, the disease agents may have been present without having been diagnosed by a veterinarian or laboratory. *Haemophilus parasuis* is associated with respiratory problems primarily in nursery pigs (Nicolet, 1992b). *Haemophilus*

pleuropneumonia (also called *Actinobacillus pleuropneumoniae* and *Haemophilus parahaemolyticus*) is associated with pleuropneumonia and pleuritis in pigs (Fenwick et al., 1986; Nicolet, 1992a). Although the questionnaire asked only about *Haemophilus* without specifying the species, it is likely that most producers who reported *Haemophilus* in finisher pigs were refering to *Haemophilus* (or *Actinobacillus*) *pleuropneumoniae* rather than *Haemophilus parasuis*. Nicolet (1992a) attributes the primary economic importance of the former disease agent to mortality and medical costs in acute outbreaks. Fenwick et al. (1986) considered this disease agent to be a major problem in the swine industry worldwide.

It is possible that producers with more respiratory problems in their pigs were more likely to seek a diagnosis and thus have *Haemophilus* diagnosed by a veterinarian or laboratory. Therefore, some information bias could be present in the results. It is also likely that many of these producers implemented some type of control measure (e.g. vaccination, depopulation/repopulation, age segregation, or other management changes) between diagnosis and providing the mortality information for the current study. Not knowing what changes took place is a limitation common to many retrospective studies. In this study, at least some of the management information was collected during an initial visit in June, 1995, and mortality information was gathered for the final six months of the year. Still, the swine industry is a very dynamic industry which is currently undergoing rapid structural transformation (Honeyman, 1996). Some of the farms in the study may well have implemented a number of management changes during the period covered by the study, and we would have no way of knowing (from the data) what they were. This study examined associations between management and other factors and mortality attributed to respiratory problems among pigs in the grower/finisher phase of swine production in the United States. Carefully controlled studies would be required to determine the exact relationship between a factor identified here and actual mortality caused by respiratory disease.

Weaning age was also important for overall mortality (Losinger et al., 1998). Longer exposure to milk antibodies and more time with the sow might improve the overall health of finisher pigs, and might result in a smaller percentage of the pigs dying from respiratory illness during the grower/finisher phase.

The finding that keeping $\geq$50% of finisher pigs only on solid-concrete flooring was associated with reduced odds of $\geq$2% mortality attributed to respiratory problems was contrary to what one might have anticipated. Slotted flooring is frequently recommended to separate pigs from their manure (Fritschen and Mueling, 1993). Lungworm (*Metastrongylus* sp.) is passed in the feces (Corwin and Stewart, 1992). Gases produced by manure can also cause respiratory problems (Bate et al., 1988). Therefore, some further investigation to study the link between solid-concrete flooring and mortality attributed to respiratory problems may be warranted.

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